THE MIDDLEBURY COLLEGE SOLAR INITIATIVE PROPOSAL

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Executive Summary

- We recommend the College install a 240 kW tracking solar array on the land parcel between Bicentennial Way and Route 125.
- We advise the College to accept the development proposal and Power Purchase Agreement submitted by AllSun Trackers, the solar division of AllEarth Renewables.
- Such an installation would add another renewable, non-carbon based resource to the College's electricity mix and aid in the Colleges goal of achieving carbon neutrality by 2016.
- A large-scale solar array would provide an invaluable educational opportunity while solidifying the College's leadership position in sustainable practices among NESCAC schools.
- The installation of a solar array would be a smart economic investment: over a projected 25-year period for a 240 kW tracking array, the College can expect a net return of $1,196,558.
- We advise the College to pursue this course of action as soon as possible: the imminent closure of the Vermont Yankee nuclear plant, coupled with a state and federal tax incentive package that expires at the end of 2010, means that there is no better time to strongly consider the addition of a solar array to the College's energy portfolio.

PART I: PROJECT OVERVIEW

Introduction

As concerns for a changing and unstable climate grow and global reserves of carbon-based fuels continue to dwindle, renewable energy sources as options for future electricity production are becoming attractive investments. In the past, wind, hydropower, and biomass have captured the majority of the focus of renewable developers and relevant legislation. More recently, solar energy has begun to garner attention, supported by increased research, government incentives, and private investment. Solar arrays are being constructed at a wide range of scales; from single panel systems designed for individual homes to commercial-scale production for corporate buildings, solar energy is becoming an important part of energy portfolios around the world.

At a glance, Middlebury College would be an ideal candidate to invest in solar energy. Given the College's stated goal of carbon neutrality by 2016, the addition of any renewable, non-carbon based energy sources to the College's portfolio would be a welcome step forward. From an educational standpoint, the installation of a solar array would allow Middlebury students a unique, hands-on set of learning opportunities that few other academic institutions can provide. Financially, the specified payback period of a large-scale solar array would negate the original up-front cost well before the end of the minimum lifetime; electricity produced after the payback period would account for a significant net profit for the College. While the rooftop solar panels on the Franklin Environmental Center at Hillcrest are a positive step to the full integration of solar in the College's energy portfolio, the inclusion of a larger array would firmly establish Middlebury as the leader of all NESCAC schools in the arena of energy sustainability.

The host of reasons to consider the installation of a large solar array is further bolstered by the current controversy surrounding the Vermont Yankee nuclear plant; the recent decision not to renew the plant's license to operate beyond 2012 could result in an increase of carbon-based, out-of-state sources in the energy portfolio for the state and the College. If Middlebury wants to maintain its position as a leader in sustainability and ecologically-sound practices, there is no better time to strongly consider the addition of a solar array to our energy portfolio.

Although the opportunity for a solar energy endeavor is clear, challenges that such an installation would face include both financial and time-scale difficulties. Solar technology is not inexpensive. While this proposal suggests several options for payback periods and attractive Power Purchase Agreements (PPA), the question of whether a large investment is a smart one will be challenging. In terms of timing, the current solar incentives set to expire at the end of 2010 make the installation savings attractive now, but uncertain in the coming years. Lastly, solar technology in the form of PV cells is always advancing in efficiency rating and lower cost. Perhaps something less expensive with a higher efficiency rating will be available in the near future making installation now obsolete. These challenges are justified concerns that this proposal will address in relation to the advantages and disadvantages of a solar array installation at Middlebury.

Project Content and Goals

This project and subsequent proposal seeks to assess the feasibility and advisability of installing some form of solar array on Middlebury College lands by the end of 2010. Ideally, these solar panels will be used in a group net-metering protocol to help offset the electricity needs for College-owned buildings not connected to the main campus network. Factors influencing the feasibility include the type of array (whether fixed or tracking), the scale of the array, and the ability to have it installed by the end of 2010—when significant government incentives for solar programs are set to expire.[1] The overall recommendation put forth by this project is based on the economic, environmental, educational, and social costs and benefits of installing a solar array.

Site Reports

We have chosen three potential sites for the Middlebury College solar energy development project. The sites represent three different types of land owned by the College: agricultural in-use, campus, and off-campus unused. These sites were chosen in consultation with Assistant Treasurer and Director of Business Services Tom Corbin and Director of Sustainability Integration Jack Byrne and were chosen based on their suitability for solar development: proximity to 3-phase power lines, size, current land use, exposure orientation, and public visibility. The sites described below are not final decisions. This analysis will simply highlight the advantages and disadvantages of developing each College-owned land type.

1. Bicentennial Way

Located on the north side of College Street, between Bicentennial Way and Blinn Lane, this 3.5-acre lot is currently unused by the College. The site is highly visible to passing traffic and is mainly hidden from view of nearby neighbors. The lot has fair southern and western exposure and is ideally situated near an existing 3-phase power line along Route 125. The lot features gently rolling topography that would require minimal landscaping.

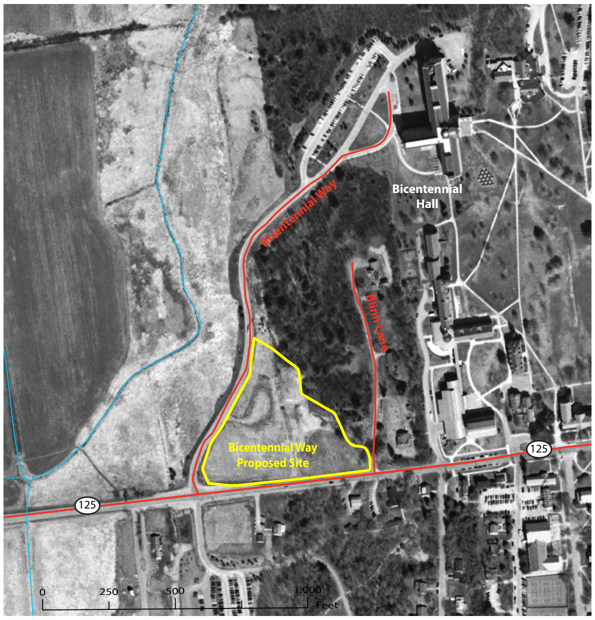


Figure 1. Bicentennial Way proposed site
Area (acres): 3.5
Maximum installed capacity (kW): >250

2. Route 7 North

This site is located on Route 7 North on the Beckwith Lot, across from the Hendy Brothers Farm Equipment store. This 8.5-acre lot is unused by the College, and cannot be developed due to its inaccessibility to water and sewage lines. The site is extremely visible to passing traffic, and is surrounded mainly by local businesses and farmland. The site has excellent southern sun exposure. It is situated half a mile from the nearest 3-phase transmission line, and would possibly require the installation of several power poles. The lot would require intermediate landscaping for flattening and vegetation removal.

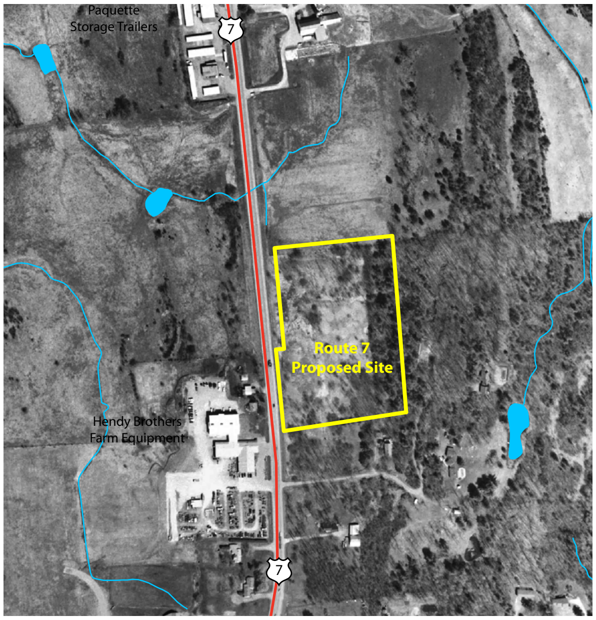


Figure 2. Proposed Route 7 North site
Area (acres): 8.5
Maximum installed capacity (kW): >250

3. South Street

The South Street site is located on Gorham Farm, just south of Porter Hospital. This 13-acre site is currently leased to farmers and used as a hayfield. The site has fair southern sun exposure. It is situated 1/3 of a mile from the nearest 3-phase transmission line, and would possibly require the installation of power poles. The site does not share the high public visibility of the other two sites, and is surrounded by many more residential properties. The lot would require no landscaping.

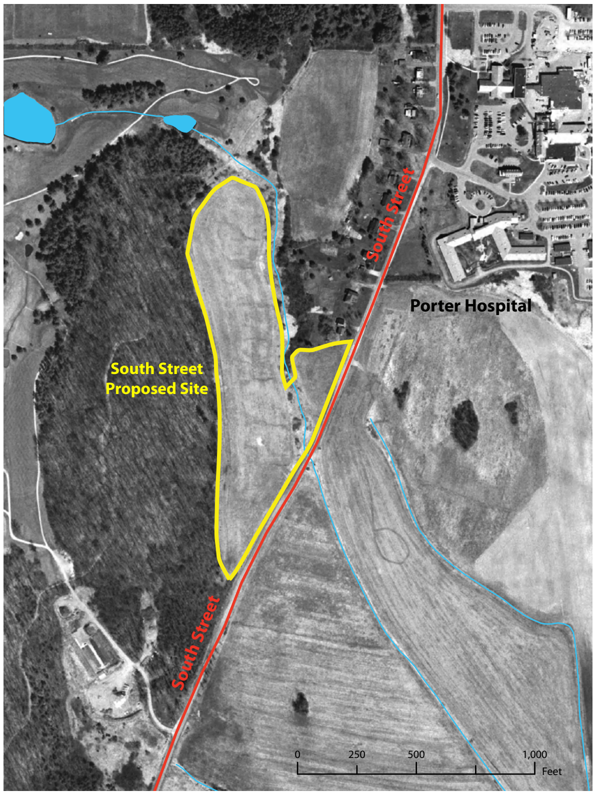


Figure 3. Proposed South Street site
Area (acres): 13
Maximum installed capacity (kW): >250

PART II: ANALYSIS

Fixed and Tracking Array Comparison

There are various technological options available for the production of solar power: one of the more recent developments has been the increased popularity of tracking arrays. These arrays follow the sun across the sky throughout the course of the day in order to increase efficiency. To determine whether this newer technology would best suit the College's needs, we compared efficiencies, land-use requirements, and cost of both fixed and tracking arrays.

Table 1. Section A shows data comparison for a 150 kW array. Section B shows data comparison for a 240 kW array. Shaded cells are constants determined from existing arrays in Vermont. Efficiency, or kWh/year/W installed, is an average taken from various sources.[2] The assumed lifetimes of the arrays are based on current panel warranties.

A. 150 kW array

	Tracking	Fixed
Area required for one module (ft^2)	2500	225
Peak power output of array (kW)	150	150
Modules per acre	17.4	193.6
kW per module	4	1.5
Cost per module	$31,000.00	$9,150.00
Number of modules required	38	100
kWh/year/W installed	1.41	1.09
kWh/year/acre	98,271	316,536
kWh/year for the array	211,500	163,500
Area required for array (acres)	2.15	0.52
Cost of array (Total)	$1,162,500.00	$915,000.00
Cost per kW	$7,750.00	$6,100.00
Assumed life-time (years)	25	25
Cost/kWh over assumed life-time	$0.22	$0.22

B. 240 kW array

	Tracking	Fixed
Area required for one module (ft^2)	2500	225
Peak power output of array (kW)	240	240
Modules per acre	17.4	193.6
kW per module	4	1.5
Cost per module	$31,000.00	$9,150.00
Number of modules required	60	160
kWh/year/W installed	1.41	1.09
kWh/year/acre	98,271	316,536
kWh/year for the array	338,400	261,600
Area required for array (acres)	3.44	0.83
Cost of array (Total)	$1,860,000.00	$1,464,000.00
Cost per kW	$7,750.00	$6,100.00
Assumed life-time (years)	25	25
Cost/kWh over assumed life-time	$0.22	$0.22

The area, kW per module, and cost per module are based on existing arrays in Vermont. The tracking array data originate from the data on the AllSun Trackers™ experimental array in Hinesburg, VT. The fixed data originate from the Central Vermont Public Service (CVPS) solar installment in Rutland, VT. The efficiency constants are an average from multiple studies on the efficiency of energy conversion on fixed and tracking arrays. These numbers are approximately equal to those provided by AllSun Trackers.

Table 1 compares various aspects of fixed and tracking arrays. The first comparison of importance is the area required for both fixed and tracking arrays—tracking modules require nearly 4 times more acreage than fixed. If spacing is an issue, the area required for each type of array should be considered. Second, the initial cost of tracking arrays is much larger than fixed at both per unit and per kW levels. This cost difference is due to the necessity of a motor and other moving parts for each module. Trackers do offset this extra cost by converting nearly 32% more energy per Watt installed (WI) than fixed arrays.[3]

Regarding the overall price and power production, fixed and tracking arrays can also be compared in relation to their respective lifetimes. If we consider the cost of a kWh over the assumed lifetime for a tracking array, the cost is equal—$0.22 for each after 25 years (the average minimum lifetime of a system). It is important to note that these numbers rely on an estimated 32% increased energy production of tracking arrays compared to fixed during a given time frame. Although tracking is initially more expensive, an expanded time frame shows a reduction in production vs. cost to rates below an initially less expensive fixed array. This assessment also assumes that all costs beyond the purchase and installment are equal and negligible. This may not be the case as tracking arrays may require unforeseen maintenance that fixed might not.

Given that the cost of production is relatively equal between tracking and fixed arrays, the motivation for solar must be considered when deciding between options. If sheer power production is the goal, more efficient tracking arrays should be installed. If land-use change is a considerable factor, fixed arrays should be selected as they use a quarter of the land that tracking arrays do while requiring less maintenance.

Solar Legislative Parameters

A solar array installation above 240 kW requires the potential client to submit an application to the Vermont SPEED program, a state-wide tax initiative for developers of large-scale renewable energy projects.[4] To date, this lottery application has already passed. Also, Middlebury College would have had to become a primary producer of solar energy, making installation for a small number of houses not practical. Any installation under 240 kW uses a net-metering system that simply substitutes the amount of energy produced by solar with the amount of energy used on the electric bill.

The permitting process for installing a 240 kW array or smaller is relatively simple. A Certificate of Public Good (CPG) is required for any building project that will affect the College's neighbors, but this process is straightforward. A small net-metering application is also required, including an interconnection study for installations greater than 150kW, but these forms are short and provide no obstacle to the project.[5]

There are economic incentives that expire at the end of the year that need to be considered for this proposal. The Vermont Investment Tax Credit (ITC) provides a 30% credit that expires at the end of 2010 and may not be renewed in coming years.[6] In addition, any net-metered renewable energy system installed in the state is exempt from Vermont's sales tax and will qualify for the Clean Energy Development Fund.[7] Using a solar provider such as AllSun Trackers will give the College access to additional business tax incentives that it would not normally qualify for as an educational entity.

Method of Payment: Power Purchase Agreement

AllSun Trackers, a division of AllEarth Renewables, proposed a 36-tracker group net-metering scenario for Middlebury College's outer buildings on CVPS's residential rate. At 150 kW, this could represent Phase One of a two-phase project that would eventually reach the 240 kW net-metering limit after the addition of 24 more trackers in Phase Two. AllSun's explanation of the Power Purchase Agreement and permitting process is cited below:

> "Since you will be installing multiple trackers at the same location, we can reduce the Power Purchase rate from $.20/kWh to $.15/kWh. (If you decide not to purchase the trackers at year 6 but renew the PPA, we would not be able to offer the same reduction and the rate would increase to the CVPS residential rate plus $0.06.) During the first 5 years of the PPA, the College will pay a small premium since CVPS has no solar incentive like GMP's $.06/kWh adder; but once the trackers are purchased, your power rate is fixed at $0.068/kWh for the next 20 years. We can offer a staggered purchase plan over years 6-10 if necessary with the PPA rate of $.15/kWh until purchased. The trackers will pay for themselves in year 14 or only 9 years after purchase at the end of year 5. I know you had said the most compelling argument would be the financial one. Although the payback does seem long, I hope the long-term financial gain in addition to all the obvious environmental benefits, will persuade your decision makers to go ahead with an installation.
>
> The permit process is not as streamlined as for smaller systems because you have to meet more criteria under the state's 248 process. I don't think we'll have an issue going to the larger size but it will depend on the site chosen as the additional criteria are primarily environmental considerations."[8]

PPA Synopsis

- There will be a reduced PPA rate of $0.15/kWh;
- Once the trackers are purchased, the College's power rate is fixed at $0.068/kWh for the next 20 years;
- The trackers will be fully paid back by year 14;
- The permitting process is not as streamlined as smaller systems, but it should not be a problem depending on what site is ultimately chosen.

Table 2. Key financial considerations based on a 150 and 240 kW installation, fixed and tracking arrays with low, expected, and high efficiencies, under the 5-year PPA proposal from AllSun Trackers. Model assumes a 5% annual increase in electricity prices, from a retail price of $0.124/kWh from CVPS in year one. Positive net returns are realized under any size and efficiency (fixed or tracking), under the AllSun proposal.

	FIXED			TRACKING			
150 kW Equipment Purchase:	($265,400)			($343,100)			**150 kW**
Performance Criteria	**Low**	**Expected**	**High**	**Low**	**Expected**	**High**	
KWh / yr	118,400 kWh	161,320 kWh	183,520 kWh	152,300 kWh	208,680 kWh	238,280 kWh	
Annual PPA Payment (5 years)	($17,760)	($24,198)	($27,528)	($22,866)	($31,302)	($35,742)	
Total Savings on Electric Bill (25 yr)	$702,688	$957,412	$1,089,166	$904,711	$1,238,488	$1,414,160	
Annual Rate of Return (25 yr)	7.70%	11.20%	12.80%	7.70%	11.30%	12.90%	
Payback Period	17 yrs%	14 yrs	13 yrs	17 yrs	14 yrs	13 yrs	
Net Return (25 years)	$347,488	$570,022	$685,126	$446,281	$737,878	$891,350	
Net Return (35 years)	$974,589	$1,424,448	$1,657,134	$1,253,674	$1,843,144	$2,153,391	
240 kW Equipment Purchase:	($431,000)			($557,000)			**240 kW**
Performance Criteria	**Low**	**Expected**	**High**	**Low**	**Expected**	**High**	
KWh / yr	192,000 kWh	261,600 kWh	297,600 kWh	247,000 kWh	338,400 kWh	386,400 kWh	
Annual PPA Payment (5 years)	($28,000)	($39,240)	($44,640)	($28,800)	($50,760)	($57,960)	
Total Savings on Electric Bill (25 yr)	$1,139,494	$1,552,561	$1,766,216	$1,467,099	$2,008,358	$2,293,232	
Annual Rate of Return (25 yr)	7.70%	11.20%	12.80%	7.70%	11.30%	12.90%	
Payback Period	17 yrs	14 yrs	13 yrs	17 yrs	14 yrs	13 yrs	
Net Return (25 years)	$563,494	$924,361	$1,111,016	$723,699	$1,196,558	$1,445,432	
Net Return (35 years)	$1,580,415	$2,309,916	$2,687,244	$2,032,985	$2,988,882	$3,491,986	
	FIXED			TRACKING			

Table 3. Key financial considerations based on a 150 and 240 kW installation, fixed and tracking with low, expected, and high efficiencies, absent any PPA or financing. Model assumes outright purchase in year 1 with no annual payments. Same assumptions as Table 2 are held in regards to electricity prices through time. Under the lowest efficiency, net losses are realized for fixed and tracking arrays, at both the 150 and 240 kW installation size.

	FIXED			TRACKING			
150 kW Equipment Purchase:	($887,000)			($1,146,000)			**150 kW**
Performance Criteria	**Low**	**Exected**	**High**	**Low**	**Expected**	**High**	
KWh / yr	118,400 kWh	161,320 kWh	183,520 kWh	152,300 kWh	208,680 kWh	238,280 kWh	
Annual PPA Payment (5 years)	N/A	N/A	N/A	N/A	N/A	N/A	
Total Savings on Electric Bill (25 yr)	$702,688	$957,412	$1,089,166	$904,711	$1,238,488	$1,414,160	
Annual Rate of Return (25 yr)	149.40%	N/A	2.10%	145.50%	N/A	2.10%	
Payback Period	22 yrs	20 yrs	19 yrs	22 yrs	20 yrs	19 yrs	
Net Return (25 years)	($185,312)	$69,412	$201,166	($242,289)	$91,488	$267,160	
Net Return (35 years)	$441,789	$923,838	$1,173,174	$565,104	$1,196,754	$1,529,201	
240 kW Equipment Purchase:	($1,439,000)			($1,859,000)			**240 kW**
Performance Criteria	**Low**	**Expected**	**High**	**Low**	**Expected**	**High**	
KWh / yr	192,000 kWh	261,600 kWh	297,600 kWh	247,000 kWh	338,400 kWh	386,400 kWh	
Annual PPA Payment (5 years)	N/A	N/A	N/A	N/A	N/A	N/A	
Total Savings on Electric Bill (25 yr)	$1,139,494	$1,552,561	$1,766,216	$1,467,099	$2,008,358	$2,293,232	
Annual Rate of Return (25 yr)	146.20%	N/A	2.10%	145.50%	N/A`	2.10%	
Payback Period	22 yrs	14 yrs	19 yrs	22 yrs	20 yrs	19 yrs	
Net Return (25 years)	($300,596)	$112,561	$326,216	($392,901)	$148,358	$433,232	
Net Return (35 years)	$716,415	$1,498,116	$1,902,444	$916,385	$1,940,682	$2,479,786	
	FIXED			TRACKING			

These matrices (Tables 2 and 3) reflect several key financial considerations and performance factors based on low, expected, and high outputs from fixed and tracking arrays at two scales: 150 kW and 240 kW. A fundamental realization of this model is that the price premium of tracking arrays over fixed arrays is directly proportional to the efficiency premium of tracking over fixed arrays. Additionally, the internal rate of return (IRR) and payback period do not change with scale. This is largely due to two factors, the first being incomplete price data available for installation costs of different scales; the second being that the only data regarding expected output from tracking arrays come from the prospective developer.

The output, according to AllSun Trackers, of tracking arrays reflects the concept of 'you get what you pay for.' That is to say, trackers cost more and produce more on the same schedule of fixed arrays. On the other hand, the data could be intentionally designed to reflect a break-even point that coincides directly with fixed arrays. One would expect that tracking arrays should deliver more than their price premium, defining a market niche, but that is a normative assumption. We used low, expected, and high outputs for each type (fixed or tracking) and size (150 or 240kW) to help model these financial considerations under various situations.

Table 2 assumes a similar PPA financing structure for fixed arrays as has been offered by AllSun Trackers for their tracking arrays. However, AllSun Trackers does not sell fixed arrays. We applied AllSuns' PPA financing structure to model a financing method for fixed arrays because we did not receive any financing proposals from developers for fixed arrays. The financial assessment changes greatly in the absence of any PPA financing, for both fixed and tracking arrays (Table 3). This is an important consideration, should AllSun's PPA offer expire at the end of 2010.

Price data for fixed and tracking arrays are given as static figures per provider quote. Installed cost for tracking arrays is modeled off AllSun Trackers' quote of $31,000 per 4kW tracking module, i.e. $7750 per installed kW.[9] Fixed arrays are modeled at $6000 per installed kW. Therefore, no economy of scale can be expressed in our model with reasonable measure. Economy of scale would reflect changing IRR and payback period according to project size.

Low, expected, and high efficiencies for fixed arrays were calculated in this study by examining 19 independent and monitored fixed arrays across New England (Tables 2 and 3). Data were gathered from Solectria Renewables database.[10] Only complete data (months with fewer than 3 days of missing data) were included in the average annual output. These annual outputs were then divided by the project size, to yield kWh per watt installed per year.

Because there are few tracking arrays installed and being monitored in New England, limited data is available for the realized efficiencies of tracking arrays. Tracking efficiency is based on the project quote from AllSun Trackers: 1.41 kWh/WI/Year. Ideally, this model would incorporate an independent analysis of a sample of tracking arrays in the region, as done with fixed arrays. The range of outputs (low-expected-high) was generated using the same proportional change as witnessed in the fixed array efficiency study.

All financial models assume a 5% annual increase in electricity prices from CVPS starting at a rate of $0.124/kWh in year one. There is, however, no consistent trend of increasing electricity rates of 5% per annum. This rate was chosen to reflect how electricity prices might increase in the future at the closing of Vermont Yankee.

Carbon Footprint Savings Analysis

Middlebury College has a stated goal of becoming carbon neutral by the year 2016. To assess the extent that the installation of a solar array would help the College move toward this goal, we compared the current, local electricity mix versus the expected changes brought on by the installation of a 240 kW array.

Table 4. Current status and projections of carbon neutrality for the outer campus houses. Projections represent expected output from the installation of 240 kW solar PV array. All estimates are based on current CVPS grid mix composition.

Source (% of CVPS Grid Mix)	kWh/year per source (current)	kWh/year per source (Fixed)	kWh/year per source (Tracking)
Biomass (1.60%)	22105	17920	16691
Hydro (37.14%)	513120	415962	387439
Nuclear (49.68%)	686371	556408	518254
Natural Gas (0%)	0	0	0
Coal (0%)	0	0	0
# 1, 2 & 4 Fuel Oil (<1%)	276	224	209
# 5 & 6 Fuel Oil (<1%)	967	784	730
Other, assume NPCC Grid (9.23%)	127520	103375	96286
ISO-NE (2.26%)	31224	25312	23576
Total consumed from CVPS	1381584	1119984	1043184
Total produced by solar PV	---	261600	338400
Percent carbon-free sources	88.42%	90.61%	91.26%

Opportunity Cost of Land-use Change

Bicentennial Way and Route 7 North Sites

The proposed Bicentennial Way site is currently unused and undeveloped by the College, and also has no future development proposed in the Campus Master Plan.[11] The Route 7 North site is also unused, undeveloped, and not planned for development. This site is generally considered undevelopable for commercial or residential use, as the engineering costs of bringing water and sewage lines to the site are prohibitively high.[12] In both cases, the installation of a solar array would not result in any negative financial effects based on land-use change.

South Street Site

The proposed site located on South Street is currently in use as a hay field leased to local farmers. Like most College leases of this type, the parcel is leased on a year-to-year basis, and will fall in and out of use based on the demands of farmers in a current year. The price of the lease to the farmer is minimal and only covers annual property taxes.[12] The development of a solar array on this property would eliminate all capacity for use as a hayfield. As a result, the opportunity cost of land-use change for this site would amount to the property taxes of the parcel, as the cost could no longer be passed onto the farmers leasing the property. It is important to note, however, that the College already pays the taxes for this particular site in years it is not leased.

When Does Solar Make Sense?

Considering current data trends (Figures 4 and 5), it is apparent that the average cost of solar installation has decreased over time while efficiency of solar has increased. Therefore, the cost of solar has never been this low and the efficiency has never been this high. There has never been a better time to invest in solar. It is important to note, however, that this trend is likely to continue. Technology is always advancing the efficiency higher and the cost lower. This fact must be taken into consideration when choosing to install PV solar. Despite the continuing trend of increased efficiencies at lower costs, the slow rate at which they are changing does not warrant unnecessary hesitation in investing in PV solar.

Figure 4. Solar electricity system cost (dollars/Watts installed) decreasing over time (n = 774).[13] This shows an overall reduction from about $16 to $8 per Watt over the 15-year period.

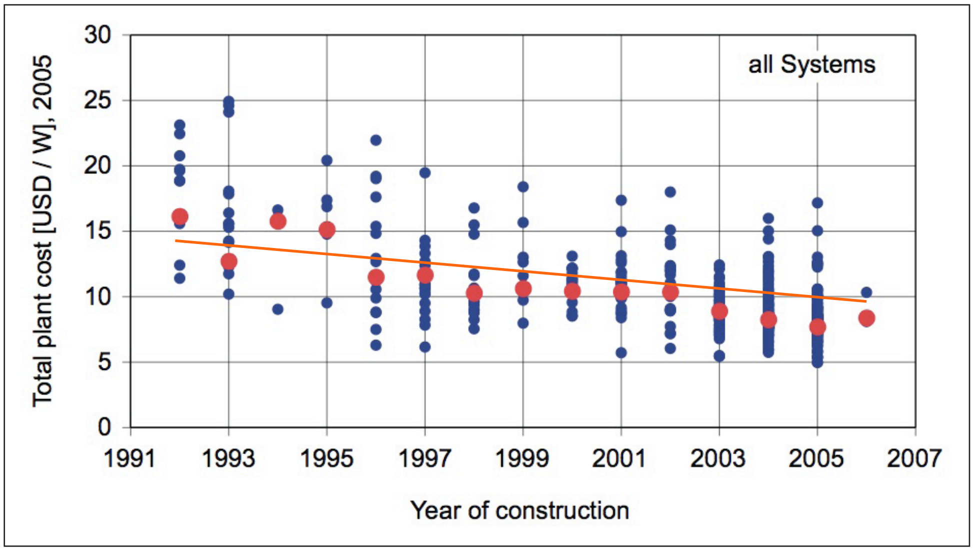
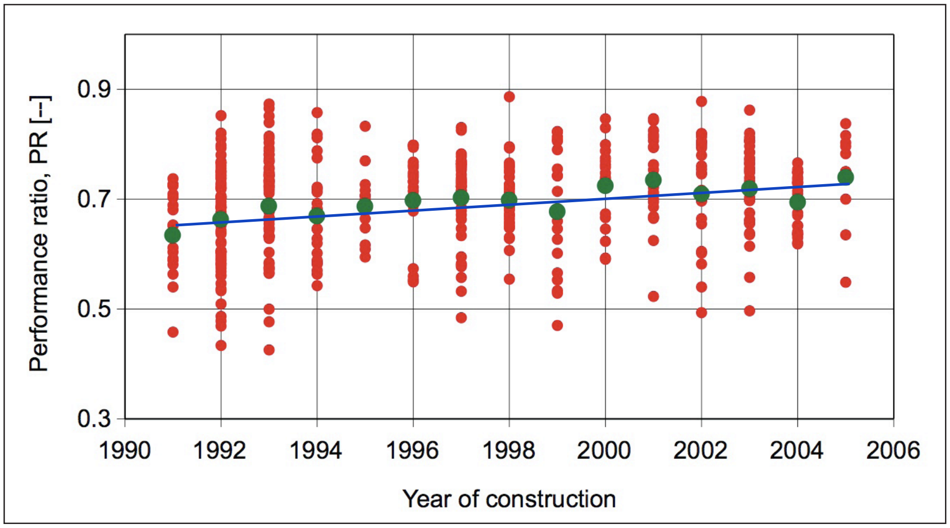


Figure 5. Solar panel performance ratio increasing over time (n = 505, total of 1,648 years data).[13]



Educational Opportunities and Public Relations Benefits

The substantial benefits of installing a solar array on campus include providing an unrivaled educational opportunity for the College and firmly establishing Middlebury College as the leader in sustainability initiatives among its peers. As it currently stands, Connecticut College is the only other NESCAC school with a solar array, and it is only 10 kW. Our proposed construction would be fifteen to twenty-five times as large, making it the largest solar array in the NESCAC (Figure 6), as well as surpassing the solar installations at Yale (Figure 7), Stanford, and MIT.[14] There is currently a surge in the number of colleges across the country installing solar arrays—this array would certainly establish Middlebury as the forerunner in sustainability among our peers, while also aiding us in our goal to become carbon neutral by 2016.

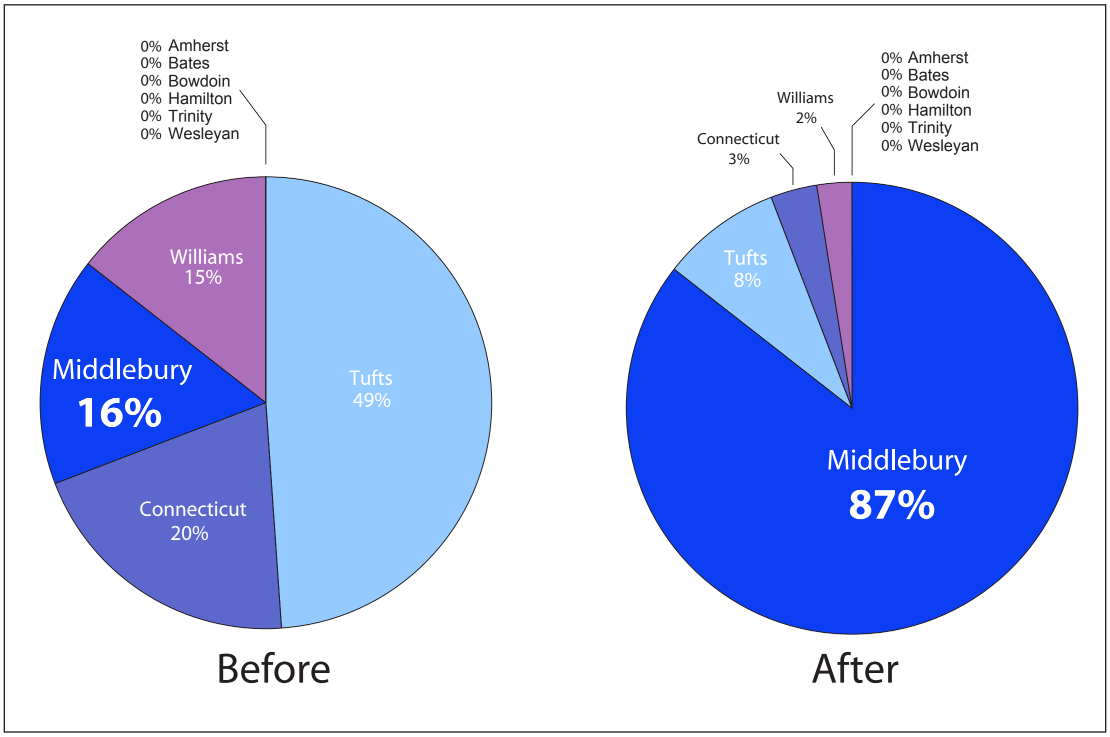


Figure 6. A comparison of installed solar electricity among the NESCAC schools. The charts show before and after the proposed Middlebury College installation of a 240 kW solar array.

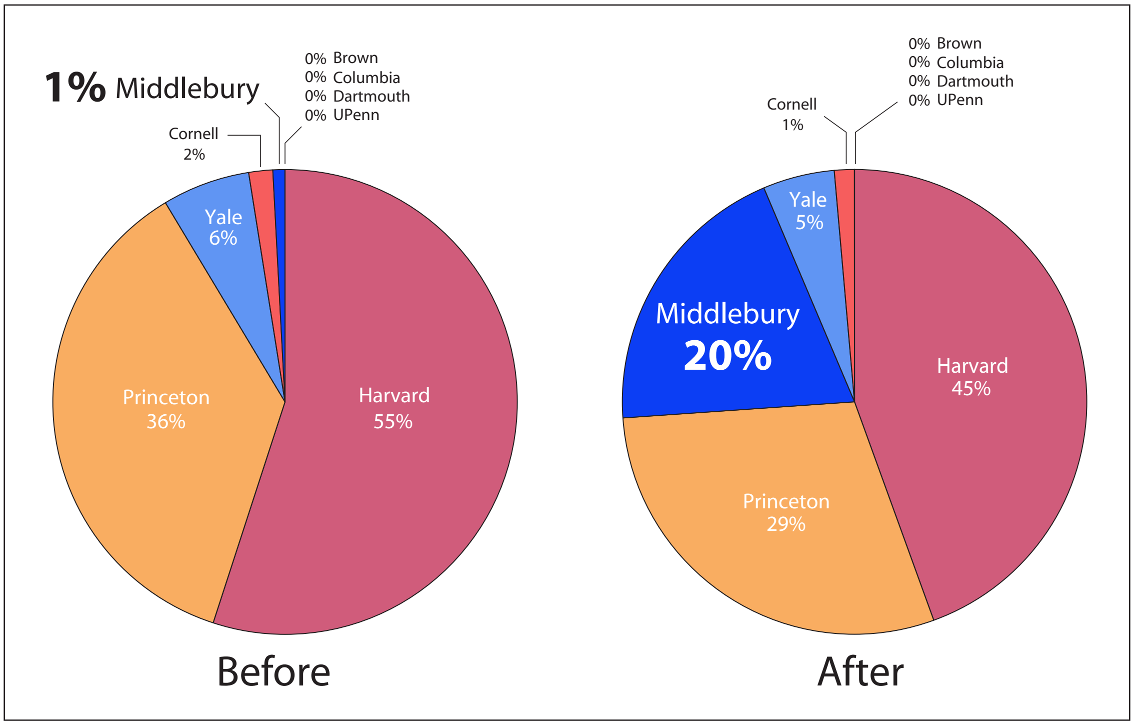


Figure 7. A comparison of installed solar electricity among the Ivy League schools with Middlebury. The charts show before and after the proposed Middlebury College installation of a 240 kW solar array.

In addition to increasing the College's reputation as a leader in sustainability, this project would provide invaluable educational opportunities for college students and the surrounding community. They would provide a visual affirmation of the College's commitment to becoming more sustainable to tour groups, visitors, and community members. Classes in the Environmental Studies and Physics departments could use the arrays as an integral part of their curriculum. Local school groups would also have the opportunity to see the College in a new light, learning valuable information about the burgeoning field of solar technology at a College that is spearheading the movement toward a sustainable future.

In an effort to gauge the reaction of some of the faculty if a large-scale array was installed, Physics Professor Rich Wolfson had this to say:

> "This would be very valuable as an educational tool. I've had a number of physics or environmental studies theses on solar photovoltaics, usually using small panels or, in one case, Hillcrest. But a system for large-scale power generation would be exciting and intellectually engaging. That said, we would have to take the time and expense to make sure the system is well instrumented. We're limited in being able to understand and study the Hillcrest system because we don't yet have sensors that look at the DC output of the panels themselves; we only know the AC power generated after the inverters."

Professor Mark Lapin, an Associate in Science Instruction in Environmental Studies, also finds an installation practical for educational purposes:

> "I have been using data from the 10 kW wind turbine and the two roof-mounted photovoltaic arrays in ENVS0112 labs for quite a few years. I would certainly use data from a larger array and would be able to incorporate that array as an educational tool in the class curriculum."

PART III: RECOMMENDATION AND CONCLUSION

Based on our analysis, we recommend a 240 kW tracking array be acquired under the AllSun Power Purchase Agreement and placed on the Bicentennial Way site before the end of 2010. The benefits associated with this type of installation include a potential seven-figure profit, increased progress towards the College's pledge to carbon neutrality, an overwhelming advantage in establishing Middlebury as the leader in solar energy production among rival schools, and numerous educational opportunities.

The Bicentennial Way site offers several advantages over the other sites assessed: it is not currently in use, it is within close proximity to 3-phase power lines for ease of transmission, and it is located close to the College. This will facilitate easier access for educational opportunities and enhance public visibility.

We recognize that the current economic climate may constrain the College's ability to invest in an array as large as 240 kW. If this is true, we suggest instead that a smaller installation of 150 kW be considered on the same site. This strategy would cost significantly less, while only reducing the magnitude of, but not eliminating, some of the potential benefits.

We understand that this recommendation demands a substantial financial decision. However, we feel that such an investment mirrors the College's commitment to a sustainable future, and would become an ideal model for state, and perhaps nation-wide, renewable energy projects.

End Notes

1. http://www.independentpowerllc.com/solar-incentives.html, April 15, 2010.
2. Fixed efficiency by College Group—Tracking efficiency cited in AllSun Trackers PPA quote to Middlebury College, 2010.
3. AllSun Trackers' PPA quote for Middlebury College, 2010.
4. http://vermontspeed.com, April 01, 2010.
5. http://publicservice.vermont.gov/energy/ee_netmetering.html, April 01, 2010.
6. http://www.leg.state.vt.us/docs/legdoc.cfm?URL=/docs/2008/bills/intro/H-520.htm, April 01, 2010.
7. Conversation with AllSun representative Caleb Elder, April 23, 2010.
8. Anne Bijur, Customer Communications of Earth Turbines, Inc.
9. AllSun Trackers' PPA quote to Middlebury College, 2010.
10. http://www.solrenview.com/cgi-bin/CGIhandler.cgi?&sort=site_name&logo, April 15, 2010.
11. Middlebury College Master Plan, 2008.
12. Interview with Tom Corbin, 2010.
13. International Energy Agency. "Cost and Performance Trends in Grid-connected PV Systems." PhotovoltaicPower Systems Programme. Report IEA-PVPS T2-06 2007.
14. Schools' solar data from Association for the Advancement of Sustainability in Higher Education website: AASHE.org.